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THE ROLE OF RESEARCH IN AIRCRAFT DEVELOPMENT

by
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It is some two years since I had the opportunity of spending a day visiting aviation leaders on the Niagara Frontier and seeing work in progress here. It is one thing to skim through voluminous progress reports of an activity; it is something else again, a stimulating and inspiring experience, to see that activity at first hand. My only regret is that time did not permit a longer and more complete study of the very substantial aviation progress being made here.

The Niagara Frontier--if you will permit me to extend its borders eastward as far as Hammondsport--can look back upon important contributions made to aeronautics over a period of nearly a half century, beginning with Glenn Curtiss' design and manufacture of engines for balloons in 1903 and 1904. And Buffalo itself, since 1915 at the latest, has been a vital factor in the nation's aviation picture. But it is not my purpose this evening to review the aeronautical history of this region; the facts are better known to you than to me.

Rather, I should like to focus our discussion upon one most important aspect of aviation, one in which the Niagara Frontier today is playing a prominent part--the translation of research into the development and production of aircraft. But first, let me recount the areas of activity and responsibility of the three principal partners who are engaged in advancing the aeronautical art: The industry, the military, and the National Advisory Committee for Aeronautics.

When it was established in 1915 by Act of Congress, the NACA was charged with supervising and directing "the scientific study of the problems of flight with a view to their practical solution" and also with directing and conducting "research and experiment in aeronautics". Those instructions were given at the same time plans were being completed in Buffalo to speed airplane production to the then unheard of rate of one per day. They were given prior to our entry into World War I, when the top speed of airplanes was something less than one hundred miles an hour, and when, according to the official record, the principal components of an airplane were "wood, sheet steel, wire, cloth, varnish".

In the 35 years since then, the science of aeronautics has become tremendously complicated. To carry research forward, our scientists have had to devise complicated and expensive tools . . . today a single wind tunnel may require 100,000 horsepower for its operation.

Over the years a pattern was evolved, wherein NACA became the principal agency in the conduct of basic aeronautical research with assistance from qualified university groups on fundamental scientific problems; the industry--making use of this research information--designed and manufactured the aircraft and operated them on the civil air routes; and the military conducted research and development in the specifically military fields, such as armament, and conducted the testing and evaluation of the newly-developed aircraft for military purposes. Actually, of course, there can be no sharply-defined dividing lines to mark off the activities of these three partners in the aviation team, but, practically, this division of responsibility and effort has worked out rather well, and must continue if the United States is to maintain its air leadership.

For some of you present tonight, the story of the full-scale high-speed research airplane program is not new, but because it is a good example of this teamwork functioning at its best, I should like to review it briefly.

By 1944, with World War II still in progress, it had become evident that if the power possibilities inherent in the jet engine were to be fully exploited, the obstacle of adverse compressibility effects would have to be overcome. These effects had been the subject of increasing study from the early twenties, by which time propeller tip speeds already had become so fast as to experience the shock waves which result from the compressibility of air.

During the war, military aircraft in dives more and more frequently attained speeds where the flow of air over the wing or tail reached the velocity of sound. The resulting behavior of the configurations then in use often led to disastrous consequences.

As we learned more about the effects of compressibility, it became apparent that two sets of physical laws had to be considered, one governing flight at speeds less than that of sound, and the other at speeds faster than sound. In addition, there is the condition of mixed flow--which occurs in the transonic region--where part of the air flow is slower than sound and part of it faster than sound.

What made the task the more difficult for the research scientists was the fact that the wind tunnel, one of the most valuable research tools, had a "blind spot" in the transonic area. Shock waves set up by a model in the test section were reflected from the tunnel walls in such a manner as to "choke" the tunnel so that gathering accurate data in this transonic speed range was impossible. Today, improvements in wind tunnel design promise to eliminate this blind spot, but in 1944 it existed as a most serious obstacle to research progress in the transonic area.

Other research techniques were devised to provide reliable information in the transonic speed range. These included the falling-body method in which a free-falling, heavily-weighted model dropped from an airplane at high altitude made possible securing considerable information at transonic speeds. Another technique used the fact that there is a region of supersonic flow over a part of the upper surface of the wing of an airplane diving at speeds of, say, seven-tenths the speed of sound. This wing-flow method has given useful data, although the scale effects were serious, because of the small size of the models which could be used, and because of the reduced air density at altitude. By installing a suitably-shaped bump on the wall of a high-speed subsonic wind tunnel, the same principle was exploited Still another of these research tools was the rocket-propelled, ground-launched research model. Here the scale effects were less because, although the model was small, density was high in the very low levels of the atmosphere where the rocket was fired.

To obtain a complete picture of what happened in the transonic speed region, to obtain answers which might be quickly applied in the design of practicable military aircraft, the full-scale, high-speed research airplane program was begun. Cooperating in this were aircraft manufacturers--including your own Bell Aircraft Corporation--the military, and NACA. Goals of the program were agreed upon, as were the basic methods of attack. Responsibilities were assigned, and by this time, five years ago, the first phases of the project were underway.

Although the airplane Bell Aircraft was to design and build was sponsored and financed by the Air Force, it was agreed that it would be built around a rocket engine developed by Reaction Motors under Navy contract. The NACA and the military laid down the basic performance specifications, but when I say this, I do not detract from the great credit due the Bell organization for the daring, imagination, engineering and construction skills it contributed.

After all, Larry Bell--I wish he could be with us this evening--and his associates, when they undertook the contract, staked their reputations on the X-1. Had the airplane been a failure, had it proven itself unable to do what was required, it would have been the Bell Company, in the last analysis, which would have suffered most. And, because I know Larry Bell and his organization are essentially realists, I am sure they were well aware of this fact.

Models of the X-1 were made and tested in NACA wind tunnels. As a result of information so gained, it was possible to collaborate in the design to assure that the airplane be as ideal as possible for the historic work it was to do. Similarly, an instrumented model of the X-1 was propelled by a rocket at the NACA Wallops Island station off the Virginia Coast, reporting by radio telemeter advance information about the aerodynamic characteristics of the prototype.

The other partners were also fulfilling their assigned responsibilities. Bell Aircraft was contributing its talents; so were the military. Bell Aircraft, incidentally, made contributions beyond the scope of its assigned responsibilities. It was from the manufacturer that the suggestion came to launch the X-1 from a B-29 "mother ship", and this novel idea, at first considered only reluctantly, has measurably increased the useful information provided by the X-1 flights. With the Air Force and the NACA now performing the research-gathering flights, and with NACA scientists providing the data-collecting instrumentation and analysis, the X-1 continues to be profitably used.

The X-1 is, of course, but one of a number of specially-designed research airplanes. Security permits me to mention two others for which Bell Aircraft has had responsibilities: The swept-wing L-39 which enabled early flight study of the take-off and landing characteristics of swept-wing aircraft, and the X-2, which has yet to fly.

Industry's participation in this program involves other companies, whose cooperation has been of similar character to that of the Bell Company. The sponsorship and financing of the research airplanes has been divided about equally between the Navy and the Air Force. As the program continues, it becomes increasingly apparent that only by this three-way cooperation can the maximum benefits be assured.

I have previously mentioned briefly other agencies which play important roles in other aspects of aeronautical research and development--the airlines and the Civil Aeronautics Administration on transport operations, and the universities on fundamental research in the many basic sciences which support aeronautical development. From its beginning the NACA has sponsored and financed research at educational and non-profit institutions as an effective supplement to the research contributions of NACA personnel. In recent years the military departments have also supported university research.

Universities have created special agencies to make more effective contributions to industrial and military research and development. One of these, the Cornell Aeronautical Laboratory, is in your own region. It has earned a well-deserved reputation in many important fields. Cornell men serve on NACA technical committees, and Dr. T. P. Wright, Vice President for Research of Cornell University, is a member of NACA. We have an excellent exchange of information and we at NACA are happy about this close and friendly relationship.

I wish now to review briefly the history of three typical research problems to indicate some of the steps between the results of laboratory research and the embodiment of that research in production airplanes.

You residents of the Niagara Frontier are well aware of the problem of ice . . . on the ground . . . sometimes for eight or nine months of the year, if reports I receive are correct. In the air, the ice problem can persist twelve months of the year. The accumulated weight is a problem, but more important is what happens to the aerodynamic effectiveness of the wings. The accumulation of ice, which can occur very quickly under certain conditions, distorts the wing shape and reduces lift to a point where the airplane cannot keep aloft. Similarly, ice can rob propeller blades of their efficiency. It can clog the air inlet of a jet engine. In many ways, ice can be a deadly hazard to airplanes.

NACA began studying the ice problem some thirty years ago. Airplanes had disappeared on flights in the North; it was suspected that these disappearances might be due to icing. The first research was carried out in flight by creating the icing conditions artificially. The research men at the Langley Laboratory in Virginia put a piece of pipe out in front of a little section of wing mounted on an airplane. By squirting water from this pipe, and flying at altitudes where the air temperature was below freezing, ice formations were built up which could be studied.

One early suggestion was to heat the leading edge of the wing to prevent formation of ice. That there was sufficient heat in the exhaust of the engine for this purpose was proven experimentally in 1931, but the time was not ripe for the acceptance of thermal de-icing and its incorporation in aircraft design Many proposals for solution of the icing problem were put forward and tried. Magic pastes were compounded and tested in flight, but rain and snow wiped them off the wing, and their effectivenss--to say the least--was very limited.

During the thirties, commercial aviation expanded greatly, and thus increased the urgency for a practicable solution to the icing problem.

The airlines reported and analyzed operating experience. Meteorologists attempted to forecast icing conditions. Aircraft designers began to consider possible devices to combat ice. NACA's part was the basic study. It involved assistance in increasing meteorological knowledge, to learn what conditions caused dangerous icing on aircraft It involved learning more about what actually happened when icing conditions occurred. It involved the reproduction of these conditions in the laboratory. It involved the actual flight of airplanes under icing conditions and the experimental design and testing of devices to make such flights possible. At the Langley Laboratory, a so-called ice tunnel was built, to permit study of the icing problem under controlled conditions. Somewhat later, both the Ames and Lewis Laboratories also worked on the problem. At Ames, flying laboratories were used, among them a C-46--doubtless built here in Buffalo--and a B-17. Heat ducts were carried to the leading edges of the wings and the control surfaces and ice formations were prevented. At Lewis, in the icing tunnel, research on propeller icing was conducted, and thermal solutions recommended.

This research effort has, one might say, "paid off". Today's transport airplanes are able to fly practically continuously in conditions of light and moderate icing, provided they are equipped with thermal de-icing equipment. NACA didn't design the specific thermal de-icing systems on these airplanes; it didn't design the transports. But it did provide basic information in its work with the industry and the military which enabled designers to successfully solve this problem.

Let me tell you about another problem. The obvious location for the air intake of a jet power plant is the nose of the fighter plane. But the nose is what might be called a preferred position. It is the nose where the designer wants to locate the radar equipment or the armament. The airplane must have guns; it must have radar. The designer has to get air into the engines. Compromises are required.

Actually, the problem of getting sufficient air to the engine has been under study for a long time. At the beginning of World War II, a fighter airplane engine needed less than a hundred cubic feet of air per second; by 1944, fighter engines were demanding 125 cubic feet per second. Today's fighter engines require almost 2000 cubic feet per second, and in the next few years, when supersonic fighters are rolling off the production lines, their engines will demand 4000 cubic feet of air per second.

The engineer has a tremendous job, providing an inlet which will efficiently handle such a volume of air. His task becomes the more difficult because his design must be tactically useful; it must provide space for the guns and the radar.

The designers need basic information . . . information that can be obtained only by study of all the possible inlet solutions. This responsibility has been NACA's work . . . research to find the advantages, and the disadvantages, of the inlet positions possible. Pressure losses, drag penalties, these are vital matters to be considered. NACA's research is made available to the nation's aircraft industry. If it were necessary for the engineering departments of each company to perform for its own purposes, such research, the costs would be prohibitive.

So far, the problems discussed have been essentially aerodynamic, the sort of work which is carried on at the Langley Laboratory in Virginia and at the Ames Laboratory in California. There is yet another large field of aeronautical research, propulsion. NACA's activities here are conducted at the Lewis Laboratory in Cleveland.

Let me mention one problem studied by the Lewis scientists. With the advent of the jet engine, it was quickly discovered that when aircraft were flown at altitude, the "fire" often went out, as the pilot would say. This forced him to come down to a very much lower altitude to restart the engine. Sometimes, he had to land his plane if the engine wouldn't start again.

This problem was poorly understood and it was limiting the altitude to which jet-powered airplanes could go. Fortunately, the Lewis Laboratory at about this time had just completed a special tunnel for the study of reciprocating engines at altitude, and this was quickly utilized in the study of the jet engine blow-out problem. This special tunnel is so constructed that the internal pressure can be reduced to simulate conditions existing at very high altitude.

NACA's part in the solution of the problem in collaboration with industry and the military services was to determine what caused the flame inside the jet engine to burn unsteadily at altitude, and finally go out, and to improve combustion at altitude. The progress made has been good; today jet engines can be operated dependably at altitudes more than twice as high as before this research program began.

The problems I have discussed are typical of those given attention at NACA. We don't design or build engines. We don't design or build airplanes. We don't design or build thermal de-icing systems. But we do build up the body of information which enables the designer to make a better product. When he discovers problems which he did not foresee, it is oftentimes possible for us to find a solution.

The design and construction of new airplanes, new power plants, new pieces of equipment which are better than those previously built is the responsibility of the industry and the military. The military services keep track of the research information and set performance goals to stimulate the industry to design greatly improved aircraft.

Under our present system there is competition among several manufacturers to come up with a new and improved aircraft. Each company has at its disposal the basic aeronautical information provided by NACA, as well as the fund of general scientific information. But what the several companies do with this information results in different designs.

Most certainly aeronautics today is a science. But it is also an art and a business in which genius, and imagination and daring are important. One manufacturer may see in the research information available to him, one avenue to the performance goals he desires. Another may see in the same facts another approach. A decade or so ago, two Niagara Frontier companies demonstrated how differently two design teams can use basic information. The Curtiss and Bell companies put forward fighter aircraft designs, built around the liquid-cooled Allison engine. The Curtiss company mounted the engine in the conventional manner, in front of the pilot, at the same time providing for the positioning of armament and other equipment as required. The Bell Company buried the engine behind the pilot, transmitting power to the propeller by an extension shaft. Out on the West Coast the Lockheed Company in its search to provide the satisfactory answer to the same fighter requirement, came up with a design which used not one, but two Allison engines.

This is duplication, the word used to mean competition. Duplication in a sense, yes, but duplication of a sort which is our best guarantee that the aircraft industry will make the best possible use of the aeronautical information available. There must be . . . and there is . . . a fair degree of coordination in this procedure whereby several companies are encouraged to offer designs which will best satisfy performance requirements. There is always the danger that duplication could become too costly, and thus unwarranted, but I feel the real danger, if one exists, is not this, but rather that the laudable efforts to achieve coordination might lead us to be content with relatively minor improvements, rather than the major advances which are possible.

The opportunities for further growth, for further improvement, are immense. Today we are on the threshhold of a supersonic era. The prospect of tactical aircraft flying at speeds faster than sound is fairly immediate. The problems still to be solved, before we can realize sufficiently long-range supersonic aircraft, are many, but they seem to be problems that are solvable, providing only we expend sufficient time and money on them.

What I have just said is not a possession exclusively American. I am sure that half-way around the world the Russians are doing something about furthering their own position in aeronautical development.

What we must do is carry on vigorously, intelligently, and without delay the research necessary to stay ahead of any potential enemy. We must translate these research gains into the development of aircraft of superior performance. We must maintain our aircraft industry in a healthy condition to enable it to produce aircraft of superior performance in the quantities required in an emergency. We must maintain our military organization in condition to make effective use of those aircraft in time of emergency.

In the world in which we live, this policy of promoting our individual and collective responsibilities as members of the aeronautical research and development team is necessary and worthy of your wholehearted and vigorous support.

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